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# CHAPTER IX. PRINCIPLES FOR HYGIENE ATMOSPHERIC POLLUTION STANDARDS
[Glava IX. Printsipy gigienicheskogo normirovaniya atmosfernykh zagryazneniy]

by

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## Hygiene Significance of Maximum Permissible Atmospheric Pollution Concentrations

In order to provide a hygiene evaluation of the degree of atmospheric pollution in each concrete case, it is not enough to know the qualitative character of the pollution and its concentration in the atmosphere. One must also have a scale which will show by how much the given concentration exceeds the permissible limit. Such scale is the maximum permissible concentration of the pollutants in the atmosphere. The maximum permissible concentrations enable the hygiene worker not only to estimate the degree of air pollution, but also to justify the need for particular measures -- purifying installations, gap zones, tall chimneys, etc. Moreover, sanitary

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norms of this type enable the hygiene worker to formulate his requirements in each concrete case quantitatively, indicating the size of the gap zone, the efficiency of the purifying installations in each concrete situation, etc. The norms also make it possible to find a quantitative expression for the degree of effectiveness of the environmental health measures that were implemented. Although the norms for the gaps between enterprises polluting the atmosphere and the boundaries of residential areas in the USSR are regulated by sanitary legislation (N101-54), nevertheless deviations from these norms in either direction are permitted in certain justified cases. The sanitary organizations requiring a method which enables them to solve the problem in each concrete case in accordance with the local situation are responsible for establishing the necessity and possibility of these deviations. The available norms for the maximum permissible concentrations of atmospheric pollutants provides them with a tool with the aid of which they can rationally solve the expert sanitation problems that were mentioned above.

The maximum permissible concentrations of various industral air pollutants were determined for a large group of substances; however, for understandable reasons, they cannot be applied to the atmosphere in residential areas. While in workshops healthy adults are subjected to these concentrations only 7-8 h daily, children, old people and sick people, who are more susceptible to various harmful and unfavorable effects, inhale the air in our cities for 24 h along with healthy adults. All this argues sufficiently for the need to considerably reduce the permissible concentrations of noxious substances in the atmosphere in comparison with the concentrations that were adopted for workshops.

Because of this, a special commission was appointed in the USSR, which developed a plan for the maximum permissible concentrations of the main atmospheric pollutants that was approved by the chief sanitation inspector of the USSR. The atmospheric pollution standards developed by the aforementioned commission are the first standards of this kind both in the USSR and also in foreign hygiene.

This makes this article particularly interesting from the methodological standpoint, since the work on the norms will continue.

Method for Rational Justification of Maximum Permissible Concentrations

The problem of norms for the purity of the atmosphere can be approached in various ways.

Some authors think that only that composition of air found in natural conditions in an environment not polluted by man can be considered as a norm. In this case, the method of determining the norms for the purity of the atmosphere is very simple -- it suffices to carry out observations of the content of particular admixtures in the atmosphere far from populated areas or in the least polluted areas in cities and establish the sanitary norms on the basis of the mean values that were obtained. It is immaterial in which magnitudes these indicators are expressed -- in concentrations or arbitrary units (for example, the amount of pollution per unit surface per unit time).

Thus, for example, Prof. R.A. Babayants wrote in 1948: "To rationally determine the gaps from an existing enterprise, the degree of air pollution must be studied at certain distances from the pollution source which were specified earlier and based on a comparison with the degree of air pollution in the control site (an area with comparatively pure air). A knowledge of the aerosol weight content is not required for this purpose."

In this approach, the hygiene norms need not be justified physiologically, the interaction of the organism and the environment need not be studied, since the criterion for the sanitary permissible norm is nature.

It is obvious that this point of view will crumble under serious criticism. There is absolutely no basis for the statement that any deviation from the mean composition of the atmosphere has a harmful sanitary effect. It is known that the effect of toxins depends on their concentration, low concentrations have a basically different effect on living organisms than high concentrations (the law when a quantititative difference becomes a qualitative difference). Therefore for each agent an effect to which the organism is indifferent can be permitted, which is optimal for some agents. For example, oxygen can be toxic in certain concentrations and indispensable for sustaining life in other concentrations.

Many chemical elements and compounds which are well known as toxins are a normal component part in the tissues of our organism or products of its metabolism. Arsenic, lead, mercury, and other toxic substances are found regularly in the tissues, fluids and excretions of the human organism. From the above, it is clear that "...each toxin has a certain limit for the effective concentrations or doses below which no harmful effect is observed ..." (N.V. Lazarev, 1938). One cannot disagree with this conclusion. Therefore, deviations from the mean typical composition of the atmosphere are permissible and atmospheric pollution norms based on a comparison with pure air are unjustified.

Many people think that to determine the maximum permissible concentrations one must start out with the practically attainable concentrations given the present level of technology. This point of view often overlaps with the

first point of view (the same author motivates his proposals sometimes using the concept "pure nature" and at other times the concept "technological feasibility. Thus, for example, Prof. R.A. Babayants (1948) motivating the maximum permissible dust concentrations in the city atmosphere wrote: "In the next 5-6 years, given the contemporary level of the technological capabilities for combatting atmospheric pollution in our industrial cities, the maximum permissible dust concentration should be up to 2 $mg/m^3$ (on the average, in summer)."

Hence, instead of a hygiene norm based on physiological data and a study of the interactions of the organism with the environment, a "norm" is proposed which is based only on technical feasibility. It is obvious that technologically feasiable concentrations can be harmless concentrations only accidentally, since these concepts are independent of one another. In the majority of cases, such norms are higher than the permissible hygiene norms, and by justifying the inadequate level of technology, hamper their development. The technologically feasible concentrations can be lower than the harmless concentration, and by insisting on them we inflict an unjustified loss on the economy. Also, in this case these norms are harmful.

The third point of view maintains that when the hygiene norms are determined the effect of a particular pollutant on the health, work capacity and feeling of a human must be evaluated. Only that concentration which does not exert a direct or indirect harmful and unpleasant effect on a human does not reduce his work capacity and has no unfavorable effect on his feelings and moods is a permissible norm. Of course, the hygiene justified maximum permissible concentration can be higher or lower than the technologically feasible concentration, since its hygiene significance is

not determined by these concepts. This of course does not imply that in individual cases these norms cannot be temporarily abandoned, provided that convincing proof is furnished that they cannot be attained at a given stage. These concessions must be tied to a definite deadline during which engineers must solve the problem of reducing the concentration of the given atmospheric pollutant to the hygiene norm. Only when this approach is used, hygiene can lead technology, showing it the direction of development (within the field of its competence), rather than trail it and approve what has already been achieved.

In developing well-founded hygiene norms, we must first take into account the direct effect of the given atmospheric pollution on man. This includes the threshold for the acute and chronic toxic effect of a given substance on man and animals. Taking into consideration the fact that in residential conditions the polluted air has a continuous effect on people for 24 h, 24-h poisoning must be used in experiments on animals whose purpose is to establish the maximum permissible concentration of the noxious substances in the atmosphere.

When the minimum active concentrations are determined, the fact that the ordinary air in cities is polluted by different substances must be taken into account. Therefore, the chambers for the chronic poisoning must be supplied with equipment for the purification of the air. After it is purified, the air must be subjected to a chemical check and then supplied to the experimental chamber (after the required ingredient was added) and at the same time to the control chamber. The air in the experimental chamber must be controlled to maintain the content of the substance that is studied. It is desirable, in view of the length of the experiment, that the chambers be

equipped with automatic devices which maintain the concentrations on the given level, and devices for the recording of the actual concentrations. The animals must remain in the experimental and control chamber all the time, except the time when they are subjected to particular examinations (blood removal, determination of weight, study of reflex activity, etc.).

Experiments on animals can also be made in natural conditions. For example, N.M. Thomson (1952) placed experimental animals in cages at various distances from an enterprise polluting the atmosphere with lead and observed at the same time at these points the lead concentration in the atmosphere. After a particular exposure, the author determined the total amount of lead in the animal tissues (spectrographically). In this way he was able to find out at which concentration the lead accumulates in the animal organism, which can be taken as a criterion for inadmissible air pollution.

Experiments made on animals of course do not exhaust the question of the maximum permissible concentrations. One must know the effect of low concentrations of noxious substances on man. Here, the public health method used in the observation of the population living at different distances from an enterprise emitting the particular pollution can be used. At the same time, dynamic observations of the concentrations of the substance which interest us at these same points must be carried out. Taking into consideration that the susceptibility to disease of the population depends on many factors (professional factors, living conditions, nutrition, etc.), the observations must be organized so that the changes that were detected in the state of health of the population can be related with a sufficient degree of confidence to the atmospheric pollution.

Some authors who studied the susceptibility of the population to disease in microregions with pure and polluted air do not analyze the question of the composition of the population at all, while it is natural to assume that the populations in regions near industrial enterprises which are more heavily polluted consist primarily of workers employed in these enterprises. Therefore, the different susceptibility to disease of the adult population in various microregions can be explained by the different occupational working conditions, the different living conditions, the composition of the population by age, etc.

The data from special examinations of the state of health of the population in the microregions with different degrees of air pollution are more convincing. When the state of health of the population is studied, the specific effect of the given concrete pollution on the human organism must be taken into account. For example, when dust rich in silica dioxide is emitted into the air, the population must be subjected to an X-ray examination. When the effects of air polluted with lead dust is studied, it is desirable to carry out observations on the dynamic elimination of the lead in urine and the feces among persons living at different distances from the area where this dust is emitted. It is important to determine during these studies the concentration which does not lead to the accumulation of lead in the human organism. When the emissions of the aluminum industry are studied, attention must be given to the calcium metabolism and the elimination of fluorine in the urine. Just as in any other type of atmospheric pollution, characteristic criteria must be selected which will become the basis of the program for the study of the population.

Population groups for which the occupational character of the changes that were detected can be eliminated must be studied. Persons who have lived in the given area for a long time must be sampled for these studies, as well as persons living at different distances from the atmospheric pollution source. When a correlation is detected between the increased concentration and the percentage of detected changes, these changes can be related to the atmospheric pollution with a certain confidence, and the concentration at which they do not occur can be determined. The latter is extremely important for the rational determination of the maximum permissible concentration.

Naturally, the data on industrial toxicology and the studies on the susceptibility of workers to disease connected with particular occupational toxins must be used on a wide scale. However, these data must be used very carefully, since the duration of the effect of poisonous substances in industrial conditions is considerably shorter than in polluted atmospheric conditions. In addition, an interrupted effect during the same total exposure is less dangerous than a continuous effect. Nevertheless, the data on the effect of industrial toxins must be used as preliminary material.

A study of the odor threshold and the irritating effect of the given atmospheric pollution on the mucous membranes in the upper respiratory tracts and on the eyes must also be studied, since they are extremely important in determining the maximum permissible concentrations. The odor threshold and the irritating threshold are only of interest in the case when they are below the threshold for the toxic effect of the given toxin. Therefore, in this case, there is no reason to renounce the determination of this threshold on volunteers. A mandatory condition in such observations is their complete harmlessness to persons subjected to the observations.

It is obvious that when the odor and irritating effect thresholds are determined, only concentrations lower than the maximum permissible concentrations for the workshop can be used. During the experiments, various gas concentrations (within the permissible limits) and also pure air must be inhaled. Taking into consideration possible adaptation, short-term observations must be made which are alternated with pauses. Some authors think that the odor threshold should be determined on animals using the method of conditioned reflexes. This proposal is totally unacceptable, since the odor thresholds in animals differ considerably from the odor thresholds in humans.

Along with the determination of the odor thresholds and the irritating effect of the atmospheric pollution in experimental conditions, the method of interviewing the population living at different distance from the emission source is often used. However, the thresholds which are obtained are considerably lower than those obtained in experimental conditions. During the investigation of the air, the maximum concentrations which sometimes occur at a given point during unfavorable conditions may not be detected. During the interview, the population will tend to remember these exceptionally high concentrations. Therefore, the complaints of the population will pertain to higher concentrations than those determined by the observer on the basis of his short-term analyses. The fact must also be taken into account that usually we will not be able to determine the maximum concentrations due to the extreme variability of the concentrations in the atmosphere. We always obtain average data for a particular time interval. One-two seconds are sufficient to determine odor by the olfactory senses.

Therefore, a person can determine the current concentration by smell which we are usually not able to determine because of the insufficient sensitivity of the analytical method. All this forces us to take a critical attitude to the data obtained from interviews of the population and the assumption that the true threshold is higher than the threshold determined from such interviews.

When we have at our disposal an on-the-spot method for sampling the air (for example, the vacuum method), useful data can be obtained by asking the persons taking the samples to record whether the odor or the irritation of the mucous membranes occurred at the instant when the air was sampled. Subsequent treatment of these data can provide valuable material for determining the odor or irritating effect thresholds.

The question may be posed to what extent hygiene must take into account unpleasant sensations connected with odor. From I.P. Pavlov's point of view, a sensation is a physiological process in the brain which may have an effect on all physiological processes occurring in the organism. For example, it is known that an unpleasant odor is often accompanied by a number of vegetative reflex reactions, interrupted breathing, nausea, headaches, and vomiting. Vegetative changes can also occur as a result of pleasant odors, rather than unpleasant ones. For example, the "stupefying" effect of flower odors is well known. Since pleasant odors undoubtedly cause vegetative reactions, the prolonged inhalation of these odors cannot be considered to be indifferent to the organism. In practice, one often encounters complaints of the population living near perfume factories or pastry factories about the odor which constantly persecutes them. The odor itself cannot be considered to be unpleasant.

Hygiene workers must take into account the fact that any irritant (pleasant, unpleasant or indifferent) becomes unpleasant, unbearable, and sometimes even pathogenic when it takes on an obtrusive compulsory character. There is no doubt that conditioned reflexes are very easily formed in response to the odors.

For example, when the inhalation of some odorous toxin is accompanied by pathological symptoms, subsequently the odor of this substance can cause poisoning symptoms in accordance with the conditioned reflex mechanism even when the concentrations are lower than the toxic effects threshold.

All these considerations lead us to confirm the validity of the hygiene requirements according to which there should be no extraneous odors in the air.

Along with the determination of the olfactory sense threshold and the irritating effect of atmospheric pollution in the determination of maximum permissible concentrations, various reflexes formed in the organism as a result of the irritation of the receptors in the upper respiratory tracts are also studied. For example, the inhalation of certain substances changes the rhythm and depth of the respiratory movements, dilates or constricts blood vessels, changes the galvanic skin reflex, the optical chronaxy, the sensitivity of the eyes to light, electrical brain activity, etc.

It is of interest to find the threshold effect of every atmospheric pollution on these physiological changes. The maximum permissible concentration must be lower than these thresholds. It should be mentioned that this point of view is not shared by all authors.

In the opinion of some authors, the basis for the hygiene norms should be the determination of thresholds for pathological changes. These

authors refer to I.P. Pavlov, who distinguished in human and animal reactions the factors in the external environment, pure physiological defense mechanisms, and pathological reactions. In the opinion of these authors, in determining these norms, we must start out with the assumption that the former are beneficial for the organism and the latter harmful. Thus, the maximum permissible concentrations must be lower than those caused by pathological changes.

We take a different point of view. The purity of the atmosphere must be such that the organism need not use its defense mechanisms. In fact, certain substances bring about a defense reflex in the form of coughs, sneezing, and tears. Can we assume that these concentrations are permissible since they bring about beneficial defense reflexes? Of course not! Those concentrations which bring about inhibition of a defense reaction in the rhythm and respiratory depth, etc. are also not permissible. The defense mechanisms are to be used in extreme cases. During unexpected and inevitable changes in the environment, their use is justified and invaluable for the animal and man. However, this does not mean that defense mechanisms should be misused and that the organism should be forced to use them constantly. It is well known that all defense mechanisms are ultimately inhibited when used for a long time intensely for purposes for which they were not intended and that they lose their defensive properties. During prolonged irritation of the mucosa, anosmia, atrophic rhinitis develop and the defense reflexes in the nasal cavity disappear temporarily or for a long period. Therefore we must not subject the defense mechanisms to prolonged physiological strain. Consequently, the maximum permissible concentrations must be lower than those concentrations which mobilize the defense reactions of the organism.

Studies carried out in the last few years have shown that for the majority of these reactions the threshold concentrations coincide with the odor threshold or that they slightly exceed it. Thus, by studying these reflexes, we subject to an objective verification the odor threshold determined by the verbal interview method. This fully justifies the practical application of the given methods to the atmospheric pollution norms.

The studies have shown at the same time that the effect on the dark-adaptation curve do not always obey this rule. In some cases, the threshold according to the adaptation measurement method coincides with the sensation threshold (sulfuric acid aerosol, chlorine) and in other cases it is considerably lower (dichloroethane, sulfurous gas, acrolein) (Table 81).

Table 81

Threshold for the effect of gases on the sensitivity of the eye to light and for odor sensation

| Наименование вещества a | Порог запаха (в мг/м³) b | Порог действия по адаптометрическому методу (в мг/м³) c | Автор d |
|---|---|---|---|
| e Аэрозоль серной кислоты | 0,6 | 0,6 | К. А. Буштуева (1957) j |
| f Сернистый газ | 1,6 | 0,6 | Ф. И. Дубровская (1957) k |
| g Хлор | 1,0 | 1,0 | М. Т. Тахиров (1957) l |
| h Акролеин | 0,8 | 0,6 | М. М. Плотникова (1957) m |
| i Дихлорэтан | 12,2 | 6,0 | М. К. Борисова (1957) n |

Key:
a. Name of substance
b. Odor threshold (in mg/m$^3$)
c. Thresholds according to adaptation measurement method (in mg/m$^3$)
d. Author
e. Sulfuric acid aerosol
f. Sulfurous gas
g. Chlorine
h. Acrolein
i. Dichloroethane
j. K.A. Bushtuyeva
k. F.I. Dubrovskaya
l. M.T. Takhirov
m. M.M. Plotinkova
n. M.K. Borisova

[Note: Commas in numerals are equivalent to decimal points]

Thus, physiological changes can occur as a result of inhalation of atmospheric pollution concentrations for which no smell or irritating effect

is felt. This makes it necessary to study, along with the determination of the odor threshold or the irritating effects on the mucous membranes, various reflex reactions of the organism including the reflex changes in the sensitivity of the eye to light.

We already mentioned that prolonged stressing of the defense mechanisms may lead to their blocking. This blocking is usually the result of an inhibition in the cortical part of the corresponding analyzer. For example, under the effect of odors, hyposmia may occur which can be relatively severe and vanish only after the organisms stayed for several days in an area with pure air. A.A. Itskovich detected a considerable reduction in the sensitivity to odors among the population living in a zone near a coke-chemical combine. A study of the function of the olfactory sense in the population exposed to various odors together with the determination of the concentration of these pollutants in the air inhaled by the population may also be used as a method which will make it possible to make more precise the maximum permissible concentrations of atmospheric pollutants.

In addition to the direct effect of the atmospheric pollutants on people, their indirect effect must also be taken into account. Smoke concentrations which noticeably reduce the transparency of the atmosphere, the illumination in residential areas, and reduce the biologically valuable ultraviolet radiation intensity, increase the number of clouds, etc. must not be permitted, since all these factors in turn have an effect on the health and well-being of people. A systematic observation of the correlation which exists between the concentration of a particular type of atmospheric pollutant, primarily suspended substances, and the changes in the transparency of the atmosphere for various spectral zones of solar

radiation and also other changes in the microclimate (for example, the number of clouds) may provide the most valuable material for the determination and justification of the maximum permissible concentrations of atmospheric pollutants.

The atmospheric pollution norms must also take into account their effect on plants. The significance of city plants for hygiene is well known. It is particularly important to mention their beneficial effect on the microclimate conditions, their role in preserving the purity of the city air, and also their beneficial effect on the feelings and moods of people. Therefore, the permissible concentrations of atmospheric pollutants must be lower than the thresholds for the plants. The observations of plants must not be limited to the recording of the state of the vegetation in a given area. A study of the long-term continuous effect of the substances which interest us under strict experimental conditions must be carried out in chambers for dynamic, 24-h poisoning with the participation of the appropriate specialists. It is not enough to confine oneself to the recording of coarse morphological changes (changes in the color of leaves, scalds, falling of leaves, etc.), but the effect of the poisoning on the carbon assimilation must also be studied.

A very important index which must be taken into account in the hygiene norms for atmospheric pollutants is their effect on the living conditions of the population. For example, P.Ye. Fedorovskiy and A.S. Zykova (1953) studied the effect of a black carbon and rubber mix plant by interviewing the population, paying attention to such complaints as the impossibility of opening the air vents in the room, the impossibility of drying the laundry in the courtyard and the rapid accumulation of dirt on curtains. There is no

doubt that a degree of atmospheric pollution during which the population is not able to air its rooms even when no direct harmful effect on the human organism has been detected is not permissible under any cirmstances from the hygiene standpoint. Some gases corrode metallic objects (chlorine) or window panels (hydrogen fluoride). Clearly, their maximum permissible concentrations must be lower than the amounts causing these phenomena, since they worsen the living conditions of the population. Etching of the windows glasses is not permissible from the hygiene standpoint, since it reduces the illumination in the rooms.

During the study of the effect of atmospheric pollutants on the living conditions in the population, it must not be forgotten that poisons in the form of dust (arsenic, fluorides) may have a toxic effect in natural conditions in concentrations which are lower than the threshold which was determined experimentally. This is explained by the fact that toxic substances in the form of dust which settle on objects, vegetation, vegetables and fruits, can be accumulated and enter the organism through the alimentary tract, in addition to the amount which enters the organism through inhalation. Therefore, as mentioned in the reports of foreign authors, in populated areas located near aluminum plants, the fluorosis phenomenon is also encountered in animals at fluoride concentrations in the atmosphere which are lower than the toxic concentrations. The combined path through which the poison is introduced must be taken into account during the determination of the maximum permissible concentration in this case.

The many points which must be taken into account in the norms for a particular atmospheric pollutant require some method for their comprehensive evaluation. The only correct approach to the total evaluation of

the harmful effect of a given concrete atmospheric pollutant is using the principle of the most sensitive spot. This means that the norms must be based on the index which is most sensitive. When a particular gas can be smelled at concentrations which are much lower than those indicating the harmful effect on man and vegetation which is acute or chronic, direct or indirect, the norms must be based on the olfactory sense threshold. When some substance emitted into the atmosphere cannot be distinguished by smell, its irritating effect on the mucous membrane or its harmful effects on the vegetation in concentrations in which it has a toxic effect on man, the norms must be based on the toxic effect threshold. When, for some substance, the most sensitive spot is its harmful effect on the vegetation, the norms must be based on the threshold for the effect on the vegetation.

In studying the problem of the harmful effect of a particular atmospheric pollutant, the hygiene significance of the so-called adaptation to toxins must be properly evaluated. For example, it is known that sulfurous gas in concentrations which cause in a person not used to the particular atmosphere nausea, causes no sensations among workers who constantly work in air polluted by sulfurous gases. However, neither case must be interpreted as a proof of the absence of a harmful effect. According to N.V. Lazarev, the adaptation to irritating gases consists of the upper respiratory tracts becoming insensitive to irritation as a result of the catarrhal state of the mucous membranes. But this does not mean that the harmful effects of the irritating gases on the respiratory tracts does not continue to the full extent or does not represent even a greater danger precisely because it is not accompanied by unpleasant sensations (N.V. Lazarev, 1938). Adaptation to well-known toxic poisons has been considered

for a long time in toxicology as a symptom of chronic poisoning (the nicotine, morphine habit, etc.). Hence, the habit which becomes permanent as a result of the chronic effects of the poisonous substances is clearly pathological. It cannot be used as a motive for lowering the hygiene requirements; on the contrary, it must be considered as a factor influencing the requirements during the determination of the hygiene norms.

Along with chronic habits, hygiene workers and physiologists are well acquainted with adaptation to odors whose effect is intense. The inhibitory processes which develop in the cortical part of the olfactory sense analyzer undoubtedly are the basis for this physiological reduction in the sensitivity to odors. It is well-known that according to I.P. Pavlov, repeated irritants of the same kind which affect the same cell, or as described by I.P. Pavlov, "chisel away at one cell" cause in it an inhibitory state. This is the reason why man ceases to smell the odor of a poisonous substance after a comparatively short time. But does this mean that the harmful effect stopped? Of course not. The poison continues to affect the organism without transmitting signals to the brain. Therefore, adaptation is a harmful phenomenon which eliminates the signaling effect of the odor.

Since the maximum permissible concentrations must be based on a set of concepts, mainly of a physiological character, it is clear that our norms must be determined for a zone occupied by people. Usually, this zone is the 1-m level above ground (taking into account the population of children). However, it must also be remembered that in modern cities the population inhabiting the upper stories of multistory buildings is also exposed to the effect of atmospheric pollution. Therefore, the maximum

permissible concentrations must equally apply to elevations corresponding to the windows of the tallest buildings.

Technological Norms for the Emission of Pollutants in the Atmosphere

Some authors think that the maximum permissible concentrations must be prescribed not for the respiratory zone of people, but for the top of the emitting chimney, since this will enable engineers to use the norms directly to calculate the permissible emission. Clearly such norms cannot be based on physiological concepts, since people never inhale the undispersed gases emitted from chimneys.

The only method used for concentration norms in an emitting chimney is to take into account technological feasibility. We do not negate the usefulness of purely technological norms for maximum permissible emissions from various enterprises. These norms must be determined by engineers and based on economic considerations. However, technological norms have nothing in common with hygiene norms. When in a given concrete case the technological norms impose more rigorous requirements on the purification of emitted pollutants than hygiene norms, no objection can be made against making them the basis for the calculation of the purification equipment and other measures which reduce the emission. On the other hand, when technological norms have lower requirements on the degree of purification of the emissions than the hygiene norms, one must insist that the hygiene norms be used in the calculations.

Another important distinction must be made between hygiene and technological norms. The concentration of the polluting substance in a chimney says nothing about the concentration of the substance in the respiratory zone of man. For the same concentration of pollutants in the chimney, in

the respiratory zone, a very high concentration which is dangerous to the health of the population can be obtained when the residence is not far from the chimney, the height of the chimney is small, the speed of the wind negligible, and the amount of pollution emitted per unit time large. On the other hand, the same concentration may be completely harmless to the population when the residence is far from the emitting chimney, the height of the chimney is sufficiently tall, the speed of the wind is high, and the total amount of pollutants emitted per unit time is small. Therefore, the technological norms which do not take into account the specific features of the local situation from the hygiene standpoint cannot be used as the basis for sanitation practice. They must be considered as an additional criterion which is used only in the case when it facilitates the observance of hygiene norms. When passing from the hygiene norms for the respiratory zone of people to the concentrations in the emitting chimney needed for the calculations of the purification equipment, appropriate computational formulas whose derivation is an urgent task must be used.

Some hygiene workers proposed differentiated maximum permissible concentrations for the residential part of a populated area and for industrial sectors. This proposal only introduces confusion. If territories built up by industrial enterprises are meant as industrial sectors, norms must indeed be determined for them, which differ from the norms for residential sectors. In USSR conditions, these norms follow logically from the sanitation norm requirements for the design of industrial enterprises (N101-54). In fact, if the pollution content in recirculated air must not exceed 30% of the concentrations prescribed for workshops, the concentrations of various pollutants in the atmosphere of the plant must not be higher

than this amount. . On the other hand, when we talk about residential sectors in an industrial area, it is clear that we have no right to prescribe for the residents of these sectors, including the children and chronically ill, other norms only because the residence was built near plants which pollute the atmosphere. Our norms, whose purpose is to protect the health of the population, must be standard for all areas of the city inhabited by the population.

Maximum Permissible Concentrations of Atmospheric Pollutants

The large amount of work carried out by Soviet hygiene workers in the last few years resulted in the determination of the maximum permissible concentrations for many atmospheric pollutants. These norms are considered to be temporary expedients and they are periodically revised as further data is accumulated. The work on the rational determination of the maximum permissible concentrations continues.

Table 82 gives data on the maximum permissible concentrations as of January 1, 1961.

The norms that were presented take into account the presence of a single pollutant in the atmosphere. However, in real conditions the atmosphere is polluted simultaneously by several components, whose number can be very large. For example, studies of the atmosphere in Detroit detected the presence of the following elements in the dust: silicon, calcium, aluminum, iron, magnesium, lead, manganese, copper, zinc, tin, molybdenum, barium, nickel, vanadium, chromium, cadmium, bismuth, beryllium, etc. (Peart and Josie, 1953).

Spectrographic studies of atmospheric dust in Cincinnati revealed the presence of the following cations and anions: aluminum, antimony, arsenic,

## Table 82

**Maximum permissible concentrations of atmospheric pollutants**

| a Наименование загрязняющего вещества | Концентрация (в мг/м³) b | |
|---|---|---|
| | c разовая | d среднесуточная |
| e Акролеин | 0,3 | 0,1 |
| f Амилацетат | 0,1 | 0,1 |
| g Ацетон | 0,35 | 0,35 |
| h Бензин (в пересчете на С) | 5,0 | 1,5 |
| i Бензол | 2,4 | 0,8 |
| j Бутилацетат | 0,1 | 0,1 |
| k Винилацетат | 0,2 | 0,2 |
| l Динил | 0,01 | 0,01 |
| m Дихлорэтан | 3,0 | 1,0 |
| n Марганец и его соединения (как марганец) | 0,03 | 0,01 |
| o Метанол | 1,5 | 0,5 |
| p Метилацетат | 0,07 | 0,07 |
| q Мышьяк и неорганические соединения (в пересчете на мышьяк) | — | 0,003 |
| r Окислы азота (в пересчете на $N_2O_5$) | 0,3 | 0,1 |
| s Окись углерода | 6,0 | 1,0 |
| t Пыль (нетоксическая) | 0,5 | 0,15 |
| u Ртуть | — | 0,0003 |
| v Сажа | 0,15 | 0,05 |
| w Свинец и неорганические соединения (в пересчете на свинец) | — | 0,0007 |
| x Свинец сернистый | — | 0,0017 |
| y Сернистый газ | 0,5 | 0,15 |
| z Серная кислота (аэрозоль) | 0,3 | 0,1 |
| aa Сероводород | 0,008 | 0,008 |
| bb Сероуглерод | 0,03 | 0,01 |
| cc Фенол | 0,01 | 0,01 |
| dd Формальдегид | 0,035 | 0,012 |
| ee Фосфорный ангидрид | 0,15 | 0,05 |
| ff Фтор и его соединения (как F) | 0,03 | 0,01 |
| gg Фурфурол | 0,05 | — |
| hh Хлор | 0,10 | 0,03 |
| ii Хлористый водород | 0,05 | 0,015 |
| jj Хлоропрен | 0,25 | 0,08 |
| kk Хром (шестивалентный) | 0,0015 | — |
| ll Этилацетат | 0,1 | 0,1 |

Key:
a. Name of pollutant
b. Concentration (in $mg/m^3$
c. Single
d. Mean daily
e. Acrolein
f. Amyl-acetic-ester
g. Acetone
h. Gasoline (in terms of C)
i. Benzene
j. Butyl acetate
k. Vinyl acetate
l. Dinile
m. Dichloroethane
n. Manganese and its compounds (in terms of manganse
o. Methanol
p. Methyl acetate
q. Arsenic and inorganic compounds (in terms of arsenic)
r. Nitrogen oxides (in terms of $N_2O_5$)
s. Carbon monoxide
t. Dust (nontoxic)
u. Mercury
v. Soot
w. Lead and inorganic compounds (in terms of lead)
x. Sulfurous lead
y. Sulfurous gas
z. Sulfuric acid (aerosol)
aa. Hydrogen sulfide

[Key continued on following page]

Key to Table 82, continued

bb. Carbon bisulfide
cc. Phenol
dd. Formaldehyde
ee. Phosphorus anhydrite
ff. Fluorine and its compounds (in terms of F)
gg. Furfurol
hh. Chlorine
ii. Hydrogen chloride
jj. Chloroprene
kk. Chromium (hexavalent)
ll. Ethyl acetate

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beryllium, cadmium, calcium, copper, iron, lead, magnesium, manganese, mercury, potassium, silver, sodium, lead, titanium, vanadium, zinc, fluorine ions, sulfate ions, chlorine ions (Cholak, Schaffer and Hoffer, 1952).

The dust from nonferrous metallurgical enterprises has a very complex composition. Organic chemistry enterprises emit a complex mixture of different compounds.

Certain atmospheric pollutants are very often combined. For example, carbon monoxide, carbon dioxide and sulfurous gas in the smoke from boilers, hydrogen sulfide, and carbon bisulfide, sulfurous gas, sulfuric acid aerosols, and nitrogen oxides are often combined in the emissions of the sulfuric acid industry.

In addition to the complexity of the emissions from individual enterprises, the fact must be taken into account that in one population area various enterprises are encountered whose emissions are superimposed on one another.

Therefore, the question of the combined effect of different substances which are present in the atmosphere at the same time arises quite naturally.

The combined effect of toxins was the basis for the scientific studies by Frei (1913) and Loewe (1928). The Soviet authors N.S. Pravdin (1934) and

N.V. Lazarev (1940) made a valuable contribution to this problem. It was established that the effect of poisonous substances can be summed, i.e. the effect is doubled in the presence of two toxins, tripled in the presence of three toxins, etc. When the effect is increased in the presence of two, three, etc. substances, less than 2-3 times, we speak about the antagonism of these substances. Finally, cases exist when the combined effect is increased by an amount greater than their simple sum. In this case, we speak of the potentiation of the toxins.

The potentiation phenomenon is encountered very rarely. Most frequently, the effects can be summed. For the time being, atmospheric pollution has almost not been studied at all from this aspect. Special experimental studies of the combined effects of atmospheric pollution must be carried out and the necessary corrections must be introduced into the tables for the maximum permissible concentrations, provided these corrections are required. The synergism which occurs during high toxin concentrations may not occur at low concentrations which are encountered in the atmosphere. Therefore, the importance of this problem must not be exaggerated.

It should be mentioned that the combined effect of sulfurous gas and sulfuric acid aerosols has been studied sufficiently well at the present time and that the necessary correction can be introduced into the maximum permissible concentrations. K.A. Bushtuyeva (1960) has shown that the effect of these two substances is additive. Therefore, she recommends that their joint effect be estimated according to the formula

$$X = A/n + B/m,$$

where A is the sulfurous gas concentration in the atmosphere, n is its

maximum permissible concentration, B is the sulfuric acid aerosol concentration in the atmosphere, and m is its maximum permissible concentration. When X is larger than 1, the air pollution exceeds the permissible limit.